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Utility of a Personal Computer Aviation Training Device for Helicopter Flight Training

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U.S. Army Research Institute

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14. ABSTRACT *(Maximum 200 words)*:

Personal Computer Aviation Training Devices (PCATDs) have recently been shown to support beginning flight training both in the private sector and the military. These positive results are for fixed-wing aircraft only. The purpose of this research was to investigate which tasks from Initial Entry Rotary Wing (IERW) training could be supported by a PCATD. A utility evaluation was performed. Sixteen aviators, representing both highly experienced and student helicopter pilots, evaluated the ability of a commercial PCATD to support IERW. Seventy-one tasks were selected from Primary and Instrument Flight Training. Aviators performed each task one or more times in the PCATD before rating it on a four-point scale. Additional data were also collected. Results showed remarkable agreement between the experienced aviators and the students. The device was judged as best able to support Instrument Flight Training, especially tasks involving radio navigation. Tasks from Primary Flight Training, especially tasks requiring hovering, were judged as less well supported. The most frequently stated positive comment was that the device would be of value in supporting the training of instrument procedures. The three most frequently cited criticisms of the device concerned narrow field of view, poor visual cues to depth, and inability to hover.

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Research Report 1787

Utility of a Personal Computer Aviation Training Device for Helicopter Flight Training

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Personnel Performance and Training Technology

FOREWORD

The Rotary-Wing Aviation Research Unit (RWARU) of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) is located at Fort Rucker, Alabama. Fort Rucker is the home of the United States Army Aviation Center (USAAVNC). The ARI Aircrew Performance Team is committed to enhancing aviation training. One means by which this can be achieved is through the optimization of simulation-augmented Initial Entry Rotary Wing (IERW) training programs. The advent of PC-based simulators and other training devices which are more reliable, simpler, and much less expensive than their predecessors, could potentially revolutionize the expansion of synthetic flight for all levels of training. A research program in this area was deemed necessary because few reliable benchmarks exist as to how this new technology can best be employed in an IERW environment.

It is widely known that the power of PC processors and the capability of commercial flight simulation software have grown dramatically at the same time that they have become less expensive. Both private and military aviation communities have noticed this trend and are seeking ways to employ it in service to their own training needs. As a result of an inquiry from MG Anthony Jones, Commanding General Fort Rucker and USAAVNC, a working group was formed to investigate if and how best to employ personal computer aviation training devices (PCATDs) in IERW training. RWARU was asked to be a member of this working group because of its expertise in aviation training research and flight simulator technology. ARI considered participation in this group to be technical advisory service to USAAVNC and covered under the Army Science and Technology Objective AVATAR or Simulation-based Aviation Training.

This report describes a utility evaluation performed by RWARU on a commercial PCATD. Interim results from this evaluation plus recommendations for possible use of PCATDs in IERW flight training were briefed to the assembled PCATD Joint Working Group and to Simulation Division Chief, Directorate of Training Doctrine and Simulation (DOTDS) at Fort Rucker in August 2001. DOTDS has since purchased the device evaluated by RWARU and is continuing to study possible future implementation of PCATDs in helicopter flight training.

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The authors would like to thank all the other members of the PCATD Study Group. The Study Group was made up of volunteers from the PCATD Joint Working Group who contributed their time, their expertise, and their creativity. These were a group of men who cared about the training of novice Army aviators and who were willing to put their effort into the examination of a new technology—often at the risk of taking heat for "playing games." The Study Group persevered and accomplished its mission thanks in large part to these individuals:

William Barker, ARI-RWARU

Stephen Crouch, Lear Siegler Services, Inc.

Thomas Flohr, Directorate of Training Doctrine and Simulation

Edward Miller, Aviation Training Brigade

Willard Vignoe, Directorate of Training Doctrine and Simulation

Dale Weiler, ARI-RWARU & CAE USA

Finally, the authors would like to thank the units at Fort Rucker that supported this research. The very capable staff of Chief of Standards, Aviation Training Brigade, put ARI in touch with experienced aviators. Company B and Company D, 1st Battalion, 145th Aviation Regiment, provided ARI with access to student aviators.

UTILITY OF A PERSONAL COMPUTER AVIATION TRAINING DEVICE FOR HELICOPTER FLIGHT TRAINING

EXECUTIVE SUMMARY

Research Requirement:

Personal Computer Aviation Training Devices (PCATDs) have recently been shown to support beginning flight training both in the private sector and the military. These positive results have been shown for fixed-wing aircraft only. The requirement of this research was to investigate which tasks from Initial Entry Rotary Wing (IERW) training, if any, could be supported by a PCATD. This requirement could be met most quickly, and with the least expenditure of resources, by performing a utility evaluation of the device.

Procedure:

Sixteen aviators representing both highly experienced and student helicopter pilots evaluated the ability of a commercial micro-simulator PCATD to support the IERW Common Core curriculum. Seventy-one flight tasks were selected from Primary Flight Training and Instrument Flight Training. Aviators performed each task one or more times in the micro-simulator before rating it on a four-point supportability scale. Additional data were gathered on general attitudes toward simulation and computer literacy. Comments and criticisms were recorded, also.

Findings:

Results showed remarkable agreement between the experienced aviators and the students. The micro-simulator was judged as best able to support Instrument Flight Training, especially tasks involving radio navigation. Tasks from Primary Flight Training, especially tasks requiring hovering, were judged as less well supported by the micro-simulator. The most frequently stated positive comment was that the micro-simulator would be valuable in supporting the training of navigation instruments and procedures. The three most frequently cited criticisms of it concerned narrow field of view, poor visual cues to depth, and inability to hover.

Utilization of Findings:

The results of this analysis, plus additional recommendations, were made available to all members of the PCATD Joint Working Group as well as other interested parties at the U.S. Army Aviation Center (USAAVNC). USAAVNC is responsible for implementing the transformation of flight training from the current legacy system to Flight School XXI. ARI continues to support this transformation with technical advisory service and research.

UTILITY OF A PERSONAL COMPUTER AVIATION TRAINING DEVICE FOR HELICOPTER FLIGHT TRAINING

CONTENTS

	Page
INTRODUCTION	1
What is a PCATD?	1
Recent Research Involving PCATDs	1
Purpose of this Investigation	3
METHOD	5
Participants in Phase One: Experienced Aviators	5
Participants in Phase Two: Student Aviators	5
Simulator	5
IERW Flight Tasks	6
Procedure	7
RESULTS	8
Flight Task Evaluation	8
General Questions	15
Positive Comments and Criticisms	16
DISCUSSION	17
CONCLUSIONS	18
REFERENCES	21
APPENDIX A. Rating Form	A-1
B. Answers to the Open-Ended Question	B-1

C. Positive Comments and Criticisms C-1

D. PCATD Study Group Report D-1

LIST OF TABLES

Table 1. Mean and Median Evaluation Ratings for IERW Flight Tasks from Experienced Aviators 9

Table 2. Mean and Median Evaluation Ratings for IERW Flight Tasks from Student Aviators 11

Table 3. Summary of Evaluation Ratings by Stage of Flight Task 13

Table 4. Top Quartile: Tasks Judged to be Best Supported by the Micro-Simulator 14

Table 5. Bottom Quartile: Tasks Judged as Least Well Supported by the Micro-Simulator 15

LIST OF FIGURES

Figure 1. Lateral view of commercial micro-simulator PCATD 6

Figure 2. Rear view of micro-simulator showing visual display 6

UTILITY OF A PERSONAL COMPUTER AVIATION TRAINING DEVICE FOR HELICOPTER FLIGHT TRAINING

Introduction

> According to a number of sources, consumer flight sims have become a *de facto* part of Air Force flight training. "It's almost like that's the first phase of training—you come here fully trained up on [Microsoft] flight simulator and we'll throw you into an Air Force simulator and see how you handle it." (Prensky, 2001, p. 310)

What is a PCATD?

It is widely recognized that both the power of PC processors and the capability of consumer flight simulation software have grown dramatically at the same time that they have become less expensive. Both the private and the military aviation communities have noticed this trend and are seeking ways to harness it in service to their own training needs. This has lead to the personal computer aviation training device (PCATD). In their review of this technology, Koonce and Bramble (1998) note that PCATDs run the gamut from desktop devices to flight simulators complete with cockpit shells and full instrumentation.

In the aviation training literature, the acronym PCATD usually refers to a relatively inexpensive, fixed-platform flight simulator based on microchip processing technology and commercial-off-the-shelf, consumer-oriented software. These devices run on standard desktop PC-based operating systems such as the various versions of Microsoft Windows™. The out-the-window view is shown on the host computer's CRT screen. Usually, flight and navigation instruments are also shown on the host's CRT screen as well. Some systems provide separate screens for instruments or actual instruments mounted in a simulated cockpit shell. Although the consumer software allows for flight to be controlled from a standard PC keyboard, this is seldom used in the training literature. Flight controls are usually separate hardware consisting of some combination of flight stick and rudder pedals, control yoke and rudder pedals, cyclic and pedals (for helicopter applications), as well as a throttle or collective with throttle (helicopter). Some systems are sold as a complete cockpit with a seat, instruments, controls, large CRT screen, and separate speakers; while others rely on the user's chair, the host PC's built-in speaker, screen, and separate add-on flight controls. Most PCATDs sell for less than $10,000--often much less--making them orders of magnitude less expensive than the flight simulators historically sold by major manufacturers for civilian or military training applications.

Recent Research Involving PCATDs

Recent research, both in the private sector and the military, has investigated the value of using PCATDs for fixed-wing flight training. Ortiz, Kopp, and Willenbucher (1995) investigated the effectiveness of PCATDs for training instrument flight skills in a sample of 26 students at the Lufthansa Pilot's School. Two matched groups of students were compared. One group received part of their instrument training in a PCATD while the other group received the standard course of instruction using an approved procedures trainer. No statistically significant

differences in flight performance were observed between the two groups at the end of course check ride. The total cost of the PCATD, however, was only three percent of the cost of the certified procedures trainer.

Taylor, Lintern, Hulin, Talleur, Emanuel, and Phillips (1997) in a large, well-designed study reported positive transfer of training from PCATDs to airplane for instrument flight tasks. Their experiment involved 144 participants taking instrument flight training courses at the University of Illinois. They measured both trials to criterion in the aircraft and time to criterion in the aircraft. Using these data the authors calculated percent transfer and transfer effectiveness ratios (TERs). They found statistically significant positive transfer in seven flight lessons with percent transfer ranging from 15% to 33% and TERs ranging from 0.16 to 0.39. These results imply that for every 2.5 to 6 trials of training in the PCATD, 1 trial in the Beechcraft Sundowner was saved. Taylor et al. concluded that the PCATD is an effective training device for teaching instrument tasks to private pilots.

Dennis and Harris (1998) reported positive transfer of training from desktop PCATD practice to the aircraft for a small sample of simple visual flight maneuvers. These authors employed 21 participants, none of whom had had any prior flight experience. The members of the PCATD group received a total of one hour of training on the desktop simulator prior to their test flight in a Beagle Pup 121 airplane. Compared to a control group that did not receive the simulator training, the PCATD group demonstrated significantly better performance in straight-and-level flight as well as in exiting turns. There are two reasons for mentioning this experiment. First, transfer was shown for visual flight tasks. Second, this significant positive transfer was shown after a single hour of training with the PCATD.

Koonce and Bramble (1998) reviewed the history and present status of the use of PCATDs for fixed-wing flight training. They made a number of separate points that will be paraphrased here. First, instrument training has long been an area of flight training that has benefited from simulation. Readers are no doubt aware that the Link Trainer or "blue box" began institutional use prior to World War II. Second, Koonce and Bramble reviewed Air Force research that showed as early as 1966 that procedural tasks, such as instrument flight tasks, were far more likely to transfer well to the airplane than were perceptual-motor flight tasks, such as stick and rudder skills. Third, simulator technology continues to improve. Thus, what appear to be "aviation games" today (i.e., PCATDs) surpass in power and fidelity what were state-of-the-art full-mission simulators in 1970. Finally, the authors reported two studies that showed positive transfer of training from PCATDs to airplanes for instrument tasks and one study that showed positive transfer from PCATDs to airplanes for visual flight rules (VFR) tasks. The point is that PCATDs appear to be following in the footsteps of earlier flight simulator technology. They begin as games, then demonstrate their validity for instrument flight training, and finally move on to simulating visual (contact) flight for ground-school institutional training.

In keeping with this trend, and based in part on the Taylor et al. (1997) research, the Federal Aviation Administration (FAA) authorized the use of PCATDs to satisfy part of the creditable training requirement for the private pilot instrument rating. The details of this approval are described in the FAA Advisory Circular #61-126 (1997). The key provisions of the FAA approval are these: If the PCATD meets FAA guidelines, and if the instruction is by an

FAA Certified Flight Instructor, then said PCATD instruction can be used to satisfy as many as 10 of the 20 simulator hours creditable for instrument rating in part 61 (or as many as 10 of the 15 simulator hours creditable for instrument rating in part 141) of FAA Regulations.

In order for a PCATD to qualify for FAA approval, extensive physical controls must be present. These include: A physical, self-centering displacement yoke or control stick that allows continuous adjustment of pitch and bank; physical, self-centering rudder pedals that allow continuous adjustment of yaw; a physical throttle lever or power lever that allows continuous movement from idle to full power settings; and physical controls for as many as 12 other items applicable to the aircraft being replicated, such as flaps and navigation radios for example. Interestingly, Koonce and Bramble (1998) state that in their review of the literature they could find no scientific evidence supporting the requirement for the 12 additional physical controls mentioned above.

The Chief of Naval Education and Training has undertaken a project to identify and apply commercial PC gaming and simulation technology as a potential training tool. Dunlap and Tarr (1999) reported one outcome of this project that generated considerable interest in military training circles. They configured 10 simulator workstations as Navy T-34C fixed-wing training aircraft. Fifteen scenarios were developed including familiarization flights, basic instruments, and navigation instruments. Microsoft Flight Simulator 98™ software was augmented with an instructional framework that provided a demonstration of each scenario narrated to point out key visual and timing events. After the demonstration, student pilots were afforded the opportunity to practice the scenario. Participation in this training experience was entirely voluntary and performed at a time that would not interfere with the primary flight curriculum. Results from this initial test were positive. Participating students were significantly more likely to score highly during flight training and significantly less likely to "wash out" of flight training, when compared to their peers who did not participate. However, this initial study did not contain a control group—a fact freely admitted by the authors. Thus, it is impossible to know if practice with the PCATD helped the participating students, or if the best students were the ones who chose to participate.

Schneider, Greene, Levi, and Jeffery (2001) of the Air Force performed a controlled experiment comparing standard flight instruction to standard flight instruction plus PCATD practice. They compared the flight training performance of 55 students who were provided with access to PCATDs with that of 209 students who received standard training. The two groups of students were compared on their learning of nine advanced contact flight maneuvers such as loop and barrel roll. There were two measures of trials to criterion for each task and two measures of variability for each task. Although performance on all four measures favored the PCATD group in absolute magnitude, the small differences were statistically significant in one case only. Overall, the PCATD group showed significantly less variability than the control group.

Purpose of this Investigation

The positive results noted above were all obtained for fixed-wing aircraft. To date the authors have uncovered no published research employing PCATDs in introductory helicopter flight training. This explains the need for the current study.

Desk Top Simulators L.L.C. of Fort Worth, Texas loaned two identical devices, called Rapidly Transferable Cockpits (RTCs), to the Directorate of Training, Doctrine, and Simulation (DOTDS) at Fort Rucker for an initial 90-day examination period. The Army Research Institute for the Behavioral and Social Sciences (ARI) was asked to evaluate these two PCATDs. Throughout this report the devices will be called "micro-simulators" in keeping with the usage established by Dunlap and Tarr.

Bell and Waag (1998) listed three categories of approach for evaluating the training effectiveness of flight simulators. Utility evaluations are the easiest and quickest. Subject matter experts perform specific tasks or missions in the simulator and then rate the effectiveness of the simulator for training. The second category is in-simulator learning. Novices practice tasks in the simulator and thereby show learning through an improvement in performance. Typically the method is one of pre-test, practice, and then post-test. In this case, practice in the simulator can be shown to produce an improvement in performance in comparison to an appropriate control group. The third category is transfer of training. Here the trainee is transferred to a new environment, such as an actual aircraft, after training in the simulator. The goal is to show that the skills learned in the simulator improve performance in the aircraft in comparison to a control group not pre-trained in the simulator. Transfer of training is an excellent method to evaluate the training effectiveness of a simulator although it is resource intensive—requiring students, instructors, aircraft, and time.

The present investigation was a utility evaluation, a rapid test of an existing micro-simulator by users (cf., Nielsen, 1993). ARI was primarily interested in discovering what Initial Entry Rotary Wing (IERW) tasks could be supported for training by this device. This investigation was part of a larger examination of flight training at the U.S. Army Aviation Center (USAAVNC) at Fort Rucker. ARI chose to employ the technique of a utility evaluation in order to provide USAAVNC with reliable information in a timely manner.

The evaluation proceeded in two phases that were identical in all respects except for the category of aviator doing the behavioral evaluation. Phase one included experienced aviators while phase two used student aviators. This allowed the micro-simulator to be evaluated by people who were representative of the instructors and the students who would potentially use it. In brief, an attempt was made to have the micro-simulator under investigation evaluated by members of the target audience of interest to USAAVNC. This issue of the target audience is important. The history of human factors engineering is rife with examples of very powerful systems that saw limited use because they were designed without input from the end user and were, therefore, inappropriate for the task or incapable of being used by the intended audience (Nielsen, 1993; Norman, 1988; 1998). ARI was determined not to make this mistake.

A decision to employ a total of 16 evaluators (6 experienced + 10 students) was based in part on the advice of Nielsen (1993). Research by Nielsen concerning the optimal number of participants for usability testing has shown that 15 are sufficient. Ninety percent of the usability problems to be found will be found by 15 evaluators. Sample sizes larger than this increase testing costs without producing significant increases in benefits.

Method

Participants in Phase One: Experienced Aviators

Six experienced helicopter pilots evaluated the micro-simulator. All were male. They ranged in age from 33 to 55 years, with a mean age of 43.2 years (median 43 years). All were rated Army pilots. Their total aircraft flight hours ranged from 1153 to 5500 with a mean of 2742.2 hours (median 2400). Five of the six were current or former instructor pilots (IPs), current or former standardization IPs, or current or former maintenance test pilots. All six were rated in various models of the UH-1, five in various models of the OH-58, four in various models of the AH-1, four in the TH-55, two in various models of the AH-64, and one each in the OH-13, the TH-67, and various single-engine, piston-powered Cessna aircraft. At the time of the evaluation, the U.S. Army at Fort Rucker employed all six in some training-related capacity.

Participants in Phase Two: Student Aviators

Ten student pilots participated in this phase of the evaluation. Nine were male and one was female. Four were commissioned officers (2LT) and six were warrant officers (WO1). They ranged in age from 20 to 31 years with a mean age of 26.4 years (median 27.5 years). Their total aircraft flight hours ranged from 78 to 500 with a mean of 144.6 (median 120). All ten had completed Primary Flight Training Stage I, Primary Flight Training Stage II, Instrument Flight Training Stage I (Basic Instruments), and Instrument Flight Training Stage II (Advanced Instruments). Five were awaiting assignment to the last phase of IERW training called Basic Combat Skills. The remaining five had completed Basic Combat Skills and were awaiting assignment either to the Officer's or the Warrant Officer's Basic Course. Thus, all student evaluators had just completed that portion of the flight-training curriculum for which the micro-simulator in question was being evaluated for possible use.

Simulator

Each RTC weighed approximately 500 pounds (227 kg.). Its dimensions were 72 inches (183 cm.) in length, 34 inches (86 cm.) in width, and 60 inches (152 cm.) in height. It used standard 110 V, 60 Hz power. The visual display monitor measured 28 inches (71 cm.) diagonally. The angular field of view of this screen from a normal sitting position was 43 degrees (horizontal) by 34 degrees (vertical). This CRT screen had a resolution of 768 pixels horizontally by 1024 lines vertically. The RTC was capable of supporting a wide variety of PC-based flight simulator software applications. This evaluation was limited to Microsoft Flight Simulator 2000™ Professional Edition employing the Bell 206B Jet Ranger. The software was run on a Microsoft Windows 98™ operating system. The host computer was an Intel Pentium III™ Processor, operating at a speed of 550MHz, with 256MB RAM. The system included a Logitech wireless keyboard, a Logitech wireless mouse, and two Juster Multimedia speakers. The RTC contained a padded seat facing the CRT screen and operational flight controls. The cyclic was a Stick II made by Flight Link. Flight Link also made the collective and the pedals. Figures 1 and 2 show a lateral view and a rear view, respectively, of an RTC emplaced at the ARI test facility on Fort Rucker.

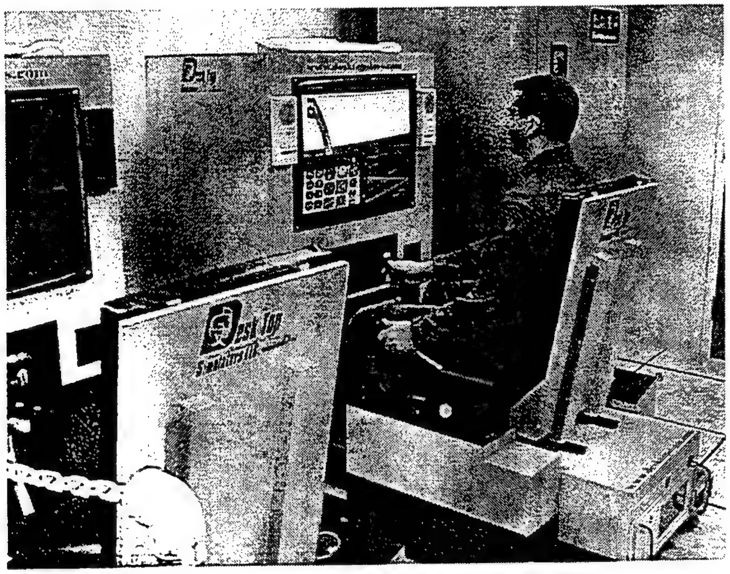

Figure 1. Lateral view of commercial micro-simulator PCATD.

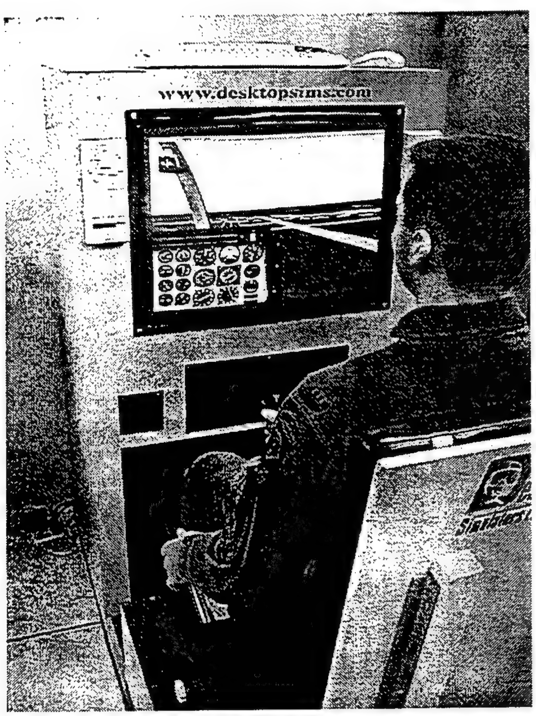

Figure 2. Rear view of micro-simulator showing visual display.

IERW Flight Tasks

Seventy-one IERW flight tasks were chosen for evaluation. All tasks were taken from IERW Flight Training Guides (USAAVNC, November 1999; USAAVNC, February 2001). Twenty-nine tasks were selected from Stage I of Primary Flight Training. Six tasks were selected from Stage II of Primary Flight Training. Thirteen tasks were selected from Stage I

(Basic Instruments) of Instrument Flight Training. Twenty-three tasks were selected from Stage II (Advanced Instruments) of Instrument Flight Training. These 71 total tasks constitute virtually the entire portion of the specifically flight-oriented curriculum. Non-flying tasks such as "Review DD Form 365-4" and "Prepare Performance Planning Card" were not included. The 71 tasks are listed in Appendix A, Part I.

Primary Flight Training (sometimes called "contact flight training") is the student's first experience with flying the aircraft. Primary Flight Training tasks are referred to as "VFR" or visual flight rules tasks. The student aviator flying VFR is primarily using his or her out-the-window view and ground references to control aircraft maneuvers. Examples of such tasks are "straight-and-level flight" and "takeoff to a hover."

Instrument Flight Training involves "IFR" or instrument flight rules training. In IFR flight, the student aviator is primarily using his or her flight and navigation instruments as the references to maintain control of aircraft attitude, altitude, and direction. Basic Instruments concerns training the use of flight instruments to control the aircraft and maintain proper attitude in the absence of visual cues. Advanced Instruments concerns the use of radio navigation instruments in addition to, and in conjunction with, flight instruments. Examples of tasks taught as part of Basic Instruments are "standard rate turns" and "unusual attitude recovery." Examples of tasks requiring navigation instruments are "Automatic Direction Finder (ADF) course tracking" and "Very High Frequency Omni-Directional Radio Range Receiver (VOR) approach." (A list of acronyms can be found on the last page of Appendix D.)

Procedure

All participants were briefed on their role in this evaluation. They were asked to evaluate the micro-simulator in terms of how well it supported the 71 specific IERW Common Core flight tasks. They were asked to provide one evaluation for each task. The four possible levels of evaluation for each task were "Not at all," "Slightly," "Moderately," and "Well." An example of the questionnaire employed is provided in Appendix A, Part I.

Each participant was given an opportunity to operate ("fly") the micro-simulator until he or she was comfortable with it. When the aviator was ready, the formal evaluation period began. The tasks were listed on the questionnaire in the order they appeared in the Flight Training Guides (FTGs). Usually the ARI researcher named a task from the questionnaire, the participant performed it in the simulator one or more times, and then offered an evaluation score. FTGs were available if an aviator wanted to check the published performance criteria prior to attempting a task, and many did so. Many aviators, however, performed the tasks in their own idiosyncratic order calling out to the researcher what they were doing and then, when finished, offering their evaluation. Thus task presentation order was not held constant across all participants and so no order effects are implied by the results. Evaluators frequently verbalized their concerns or comments while operating the simulator. The researcher noted these concerns and comments on paper and asked questions when necessary. Although an effort was made to have all 16 aviators evaluate all 71 flight tasks, this was not always possible because of time constraints.

After the flight task evaluation portion each aviator was asked some general questions about simulation, PC flight simulators, personal PC usage, and how best to use this micro-simulator in IERW training. These questions are found in Appendix A, Part II. Two short breaks were taken during the evaluation period. The entire procedure required four hours of concentrated work.

Results

Flight Task Evaluation

The data were aggregated by task and by participant both for the experienced aviators and for the students. Mean and median ratings were calculated for each task. An evaluation of "Not at all" was rated 0, an evaluation of "Slightly" was rated 1, an evaluation of "Moderately" was rated 2, and an evaluation of "Well" was rated 3. The mean rating, the median rating, and the number of evaluations on which those ratings were based are presented in Table 1 for the experienced aviators and in Table 2 for the student aviators. Tables 1 and 2 provide a detailed account of how the two groups of aviators evaluated the ability of the micro-simulator to support flight training on a task-by-task basis.

Table 1

Mean and Median Evaluation Ratings for IERW Flight Tasks from Experienced Aviators

Flight Tasks	Mean Rating (0 to 3)	Median Rating (0 to 3)	N (0 to 6)
Primary Flight Training Stage I			
Straight-and-level flight	2.00	2	6
Climbs and descents	1.83	2	6
Turns	2.00	2	6
Acceleration/deceleration	2.17	2	6
Climbing and descending turns	1.83	1.5	6
Relationship of the flight controls and the instruments	1.83	1.5	6
Hover check	0.33	0	6
Hover power checks	0.17	0	6
Rectangular course	1.67	1.5	6
"S" turns	1.83	1.5	6
Hovering flight	0.33	0	6
Takeoff to a hover	0.40	0	5
Hovering turns	0.17	0	6
Landing from a hover	0.50	0.5	6
Traffic pattern flight	1.60	1	5
Traffic pattern entry	1.20	1	5
Traffic pattern exit	1.40	1	5
VMC takeoff (hover)	0.33	0	6
VMC (normal) approach (hover)	0.50	0.5	6
Approach termination procedure	0.80	1	5
Standard autorotation	0.75	0.5	4
Simulated engine failure at altitude (autorotation descent)	1.75	2	4
Power recovery	1.75	1.5	4
Go-around	2.25	2.5	4
VMC takeoff (ground)	1.67	2	6
VMC (normal) approach (ground)	1.33	1.5	6
Hovering autorotation	0.00	0	5
Simulated engine failure at hover altitude	0.40	0	5
Shallow approach to a run-on Landing	2.00	2	5
Primary Flight Training Stage II			
Simulated maximum performance Takeoff	2.50	2.5	4
VMC (steep) approach	1.25	1	4
Slope operations	0.00	0	4
Termination with power	2.00	2	4
Low-level autorotation	1.25	1.5	4
Standard autorotation with 180-degree turn	0.75	0.5	4

Table 1 (Continued)

Flight Tasks	Mean Rating (0 to 3)	Median Rating (0 to 3)	N (0 to 6)
Instrument Flight Training Stage I (Basic Instruments)			
Straight-and-level flight	2.17	2	6
Standard rate turn	1.67	1.5	6
Climbs and descents	2.00	2	6
Timed turns	1.83	2	6
Steep turns	1.83	2	6
Acceleration/deceleration	2.17	2	6
Climbing and descending turns	2.17	2	6
Unusual attitude recovery	2.17	2	6
Straight-and-level flight (EP)	2.50	3	6
Standard rate turns (EP)	2.00	2	6
Climbs and descents (EP)	2.20	2	5
Climbing and descending turns (EP)	2.00	2	5
Compass turns (EP)	2.20	3	5
Instrument Flight Training Stage II (Advanced Instruments)			
ADF station identification	2.40	3	5
ADF aircraft position	2.60	3	5
ADF course interception	2.60	3	5
ADF course tracking	2.60	3	5
ADF holding	2.60	3	5
ADF approach	2.60	3	5
Radio navigation	2.00	2	4
ADF missed approach	2.60	3	5
VOR station identification	2.25	2.5	4
VOR aircraft position	2.75	3	4
VOR course interception	2.00	2	4
VOR course tracking	2.00	2	4
VOR holding station	2.00	2	4
VOR holding intersection	2.00	2	4
VOR approach	2.00	2	4
VOR missed approach	2.00	2	4
LOC/ILS station identification	2.50	3	4
LOC/ILS course interception	2.50	2.5	4
LOC/ILS course tracking	2.25	2.5	4
LOC/ILS holding	2.00	2	4
LOC/ILS approach	2.25	2.5	4
LOC/ILS missed approach	2.25	2.5	4
Instrument takeoff	2.17	2	6

Table 2

Mean and Median Evaluation Ratings for IERW Flight Tasks from Student Aviators

Flight Tasks	Mean Rating (0 to 3)	Median Rating (0 to 3)	N (0 to 10)
Primary Flight Training Stage I			
Straight-and-level flight	2.30	2	10
Climbs and descents	2.40	2.5	10
Turns	2.20	2	10
Acceleration/deceleration	2.00	2	10
Climbing and descending turns	2.00	2	10
Relationship of the flight controls and the instruments	2.20	2	10
Hover check	0.56	0	9
Hover power checks	0.30	0	10
Rectangular course	1.00	1	10
"S" turns	1.70	2	10
Hovering flight	0.40	0	10
Takeoff to a hover	0.70	1	10
Hovering turns	0.40	0	10
Landing from a hover	0.70	1	10
Traffic pattern flight	0.60	0.5	10
Traffic pattern entry	1.30	1.5	10
Traffic pattern exit	1.50	2	10
VMC takeoff (hover)	1.20	1.5	10
VMC (normal) approach (hover)	0.90	1	10
Approach termination procedure	1.25	1	8
Standard autorotation	1.11	1	9
Simulated engine failure at altitude (autorotation descent)	2.40	3	10
Power recovery	2.40	3	10
Go-around	2.00	2	7
VMC takeoff (ground)	2.30	2	10
VMC (normal) approach (ground)	1.00	1	9
Hovering autorotation	0.30	0	10
Simulated engine failure at hover altitude	0.30	0	10
Shallow approach to a run-on landing	1.50	1	10
Primary Flight Training Stage II			
Simulated maximum performance takeoff	1.80	2	10
VMC (steep) approach	1.00	1	10
Slope operations	0.00	0	6
Termination with power	1.50	2	6
Low-level autorotation	0.86	1	7
Standard autorotation with 180-degree turn	0.00	0	8

Table 2 (Continued)

Flight Tasks	Mean Rating (0 to 3)	Median Rating (0 to 3)	N (0 to 10)
Instrument Flight Training Stage I (Basic Instruments)			
Straight-and-level flight	2.70	3	10
Standard rate turn	2.60	3	10
Climbs and descents	2.50	2.5	10
Timed turns	2.50	3	10
Steep turns	2.10	2	10
Acceleration/deceleration	2.50	3	10
Climbing and descending turns	2.10	2	10
Unusual attitude recovery	2.30	2	10
Straight-and-level flight (EP)	2.44	3	9
Standard rate turns (EP)	2.56	3	9
Climbs and descents (EP)	2.25	2	8
Climbing and descending turns (EP)	2.14	2	7
Compass turns (EP)	3.00	3	6
Instrument Flight Training Stage II (Advanced Instruments)			
ADF station identification	3.00	3	10
ADF aircraft position	3.00	3	2
ADF course interception	3.00	3	10
ADF course tracking	2.80	3	10
ADF holding	2.80	3	10
ADF approach	2.70	3	10
Radio navigation	3.00	3	8
ADF missed approach	2.89	3	9
VOR station identification	3.00	3	10
VOR aircraft position	3.00	3	9
VOR course interception	2.89	3	9
VOR course tracking	2.78	3	9
VOR holding station	3.00	3	5
VOR holding intersection	3.00	3	5
VOR approach	3.00	3	6
VOR missed approach	3.00	3	1
LOC/ILS station identification	3.00	3	9
LOC/ILS course interception	3.00	3	8
LOC/ILS course tracking	2.88	3	8
LOC/ILS holding	3.00	3	1
LOC/ILS approach	2.67	3	6
LOC/ILS missed approach	2.50	2.5	2
Instrument takeoff	2.56	3	9

The mean overall evaluation given by the experienced aviators for all 71 tasks was 1.72. For student aviators the mean overall evaluation was 2.00. This small difference in overall mean ratings was statistically significant (nonparametric: Mann-Whitney U test, $\underline{N} = 142$, $\underline{z} = 2.84$, $\underline{p} < .005$). The difference in overall median ratings was also statistically significant (nonparametric: Mann-Whitney U test, $\underline{N} = 142$, $\underline{z} = 2.34$, $\underline{p} < .02$). Students consistently tended to rate the

micro-simulator a little higher than did the experienced aviators in its ability to support IERW training.

Student ratings for the flight tasks were positively and significantly correlated with those ratings provided by the experienced aviators. This was true both for mean ratings (nonparametric: Spearman rank order correlation, $r_s = 0.78$, $N = 71$, $p < .001$) and for median ratings (nonparametric: Spearman rank order correlation, $r_s = 0.79$, $N = 71$, $p < .001$). That is, though the students tended to assign somewhat higher ratings, there was substantial agreement between the students and the more expert pilots as to which of the 71 flight tasks were well supported by the micro-simulator and which were not well supported. These results are shown more clearly in Table 3.

Table 3 presents the results of the evaluations summarized across the four stages of flight training (Primary Stage I & II, Instrument Stage I & II) and the two categories of aviator (experienced & students). Both experienced and student aviators rated the micro-simulator as better able to support Instrument Flight Training than Primary Flight Training. Both experienced pilots and students rated the micro-simulator as best able to support Advanced Instruments. Overall, the micro-simulator was evaluated as "slightly" able to support Primary Flight Training but "moderately" or "well" able to support the Instrument Flight Training stages. This difference in ratings favoring the ability of the micro-simulator to support Instrument tasks over Primary tasks was statistically significant both for experienced aviators (nonparametric: Sign test, $N = 6$, $X = 0$, $p < .02$) and for students (nonparametric: Sign test, $N = 10$, $X = 0$, $p < .001$).

Table 3

Summary of Evaluation Ratings by Stage of Flight Task

Stage of Flight Training Task	Experienced		Students	
	Mean	Median	Mean	Median
Primary Flight Training Stage I	1.19	1	1.34	1
Primary Flight Training Stage II	1.29	1	0.91	1
Instrument Flight Training Stage I (Basic)	2.07	2	2.43	3
Instrument Flight Training Stage II (Advanced)	2.32	2	2.89	3

These results can be further explained by a listing of the specific tasks that were rated as supported best by the micro-simulator and those that were rated as supported least. Table 4 presents the top quartile of tasks (highest-rated 25%) as judged by both experienced and student evaluators. Table 5 presents the bottom quartile of tasks (lowest-rated 25%) as judged by both groups of aviators. No tasks were included in either table for which there were fewer than four experienced evaluations or six student evaluations. The results from which Tables 4 and 5 were constructed can be found in Tables 1 and 2.

Table 4

Top Quartile: Tasks Judged to be Best Supported by the Micro-Simulator

Task	Experienced	Students
Primary Flight Training Stage I		
Go-around	X	
Primary Flight Training Stage II		
Simulated maximum performance Takeoff	X	
Instrument Flight Training Stage I (Basic)		
Straight-and-level flight		X
Straight-and-level flight (EP)	X	
Compass turns (EP)	X	X
Instrument Flight Training Stage II (Advanced)		
ADF station identification	X	X
ADF aircraft position	X	
ADF course interception	X	X
ADF course tracking	X	X
ADF holding	X	X
ADF approach	X	X
ADF missed approach	X	X
Radio navigation		X
VOR station identification	X	X
VOR aircraft position	X	X
VOR course interception		X
VOR course tracking		X
VOR approach		X
LOC/ILS station identification	X	X
LOC/ILS course interception	X	X
LOC/ILS course tracking	X	X
LOC/ILS approach	X	X
LOC/ILS missed approach	X	

Of the 18 tasks rated by the experienced aviators as best supported by the micro-simulator, 16 were part of the Instrument Flight Training curriculum. Of these, 14 were trained as part of Advanced Instruments and were tasks involving radio navigation. For the student aviators the pattern of evaluations was much the same. All of the 18 tasks rated as best supported by the students were part of Instrument Flight Training. Of these, 16 were trained as part of Advanced Instruments and involved radio navigation. Thirteen tasks were rated highest by both groups of evaluators. Of these, 12 were a part of the radio navigation curriculum. Clearly, as previously shown in Table 3, the aviators sampled in this evaluation rated the micro-simulator highest in its ability to support the Advanced Instruments stage of IERW.

Table 5

Bottom Quartile: Tasks Judged as Least Well Supported by the Micro-Simulator

Task	Experienced	Students
Primary Flight Training Stage I		
Hover check	X	X
Hover power checks	X	X
Hovering flight	X	X
Takeoff to a hover	X	X
Hovering turns	X	X
Landing from a hover	X	X
Rectangular course		X
Traffic pattern flight		X
Traffic pattern entry	X	
Traffic pattern exit	X	
VMC takeoff (hover)	X	
VMC (normal) approach (hover)	X	X
Approach termination procedure	X	X
VMC (normal) approach (ground)		X
Standard autorotation	X	X
Hovering autorotation	X	X
Simulated engine failure at hover altitude	X	X
Primary Flight Training Stage II		
VMC (steep) approach	X	X
Slope operations	X	X
Low-level autorotation	X	X
Standard autorotation with 180-degree Turn	X	X

The bottom quartile consists of the 18 tasks rated as least well supported by the micro-simulator. The list of these tasks is found in Table 5 both for experienced aviators and for students. All the tasks listed in Table 5 were from Primary Flight Training. Fifteen tasks were rated as poorly supported by the micro-simulator by both groups of evaluators. Eleven of these were part of Stage I Primary Flight Training and the remaining four were from Stage II. Clearly, as also shown in Table 3, the aviators sampled in this evaluation rated the micro-simulator as least able to support Primary Flight Training. Note also that of the total of 21 tasks listed in Table 5, 15 involved hovering. (This includes the ten with the word "hover" in their title plus approach termination procedure, standard autorotation, slope operations, low-level autorotation, and standard autorotation with 180-degree turn. These tasks all have a hovering component.) Clearly, the aviators sampled in this evaluation gave low marks to the micro-simulator in its ability to support tasks requiring hovering.

General Questions

Four questions were asked of both groups of aviators after the flight task evaluation was completed. These questions can be found in Appendix A, Part II. The first question was "All in all, I believe that simulation is an effective tool for initial flight training." Participants indicated their agreement with this statement by checking one of six boxes along a (six-point) Likert-type

scale. The choices were "Strongly Agree," "Agree," "Agree Somewhat," "Disagree Somewhat," "Disagree," and "Strongly Disagree." For both experienced and student aviators the mean and median response was "Agree." In other words, both groups of aviators agreed that, in principle, simulation is an effective tool for initial flight training.

The second question asked whether the participants had run any desktop flight simulator or aviation-related game on a PC in the past year. All six of the experts said "yes." Only four of the 10 students said "yes."

The third question assessed whether or not the participants had access to a PC at their place of residence. All six experts answered "yes." Nine of the ten students answered "yes."

The last question was an open-ended one. Participants were asked, "If you were in a decision-making capacity, how would you employ this micro-simulator for IERW flight training?" Their answers to this question, in accurate paraphrases as well as actual quotations, can be found in Appendix B. These answers were entirely in keeping with their flight task ratings. Fifteen of the sixteen evaluators expressed the opinion that the micro-simulator had value for Instrument Flight Training. Interestingly, four of the experienced and two of the students used the term "procedures," "procedures trainer," or "instrument techniques" in answering the question. Clearly, the respondents were attempting to communicate to the researcher that the machine had value as a way of practicing specific procedures for heavily procedures-driven instrument tasks.

One experienced aviator and one student expressed the opinion that the micro-simulator would be of value as a dynamic classroom teaching aid in ground school. Three students stated that the machine would be of value as a practice tool and should be available to flight students in the Learning Center at Fort Rucker.

Positive Comments and Criticisms

Aviators spontaneously reported their comments and criticisms of the micro-simulator while performing the flight task evaluations. These verbalizations were recorded, aggregated, paraphrased, and are presented in Appendix C. Comments and criticisms from all 16 evaluators were aggregated by common themes. No comment or criticism was included in Appendix C unless it was stated by at least two evaluators. A total of 5 positive comments and 14 criticisms were listed.

The most frequently stated positive comment was that the micro-simulator was an instruments trainer. It would be valuable in supporting the training of navigation instruments and procedures during Instrument Flight Training. Fourteen evaluators mentioned this theme.

The three most frequently cited criticisms of the micro-simulator concerned visual field of view (FOV), visual cues to depth, and inability to hover. All 16 evaluators commented that a helicopter flight simulator must have a wider FOV than was provided by this one. Peripheral visual cues are required for hovering tasks, traffic pattern flight, traffic pattern entry/exit, autorotation, and other VFR tasks. Fourteen evaluators stated that the visual cues to height

above ground must be improved for VFR tasks. Helicopter pilots use out-the-window visual cues to determine height above terrain for a wide range of VFR tasks such as hovering, approach, and autorotation. None of the aviators could achieve a stable hover with this micro-simulator. Twelve evaluators commented upon this deficiency directly. The simulator was reported to be much harder to hover than the helicopter itself.

Discussion

This was an evaluation of the utility of a commercial micro-simulator running a PC-based flight simulator application. It was a behavioral evaluation in the sense that aviators performed each flight task listed at least once before providing a rating. The sample of aviators who rated the device was representative of the target audience of instructors and students of value to USAAVNC. This was not a training experiment. No novice flight students were trained to criterion using this micro-simulator and then compared to some relevant control group. Further, it would be technically incorrect to generalize these findings to another micro-simulator running a different software application. However, within the constraints imposed by these limitations certain clear conclusions can be drawn.

First, there was remarkable agreement between the experienced aviators and the students in their flight task evaluations, their answers to the general questions, their positive comments, and their criticisms. This was shown by the statistically significant correlations reported for the ratings. Additionally, eyeball examination of the five tables shows this similarity. Further, the answers to the open-ended question recorded in Appendix B were similar in content between both samples. Finally, examination of Appendix C shows several themes that were expressed independently by both experts and students.

This agreement between high-time aviators and student aviators has practical consequences. It suggests that the results of this particular evaluation were so obvious that one did not need to be an expert to notice them. Also, it suggests that sometimes relatively easy-to-get student aviators might be substituted for relatively difficult-to-get subject matter experts in simulator evaluation research.

Second, the ratings argued persuasively that this micro-simulator could be used to support Instrument Flight Training in some capacity. Evaluators stated that both instrument flight tasks and navigation tasks could be trained to some extent using it. Those procedural, knowledge-based, radio navigation tasks that are trained as a part of Advanced Instruments, in particular, were judged as well supported. This conclusion drawn from Army rotary-wing aviators was consistent with prior fixed-wing research by the Navy (Dunlap & Tarr, 1999), by the private sector (Koonce & Bramble, 1998; Ortiz et al., 1995; Taylor et al., 1997), and recent FAA regulations (FAA, 1997). This conclusion may help explain the small effects of using PCATDs for practice reported by Schneider et al. (2001). They chose to investigate the training of advanced VFR tasks. Such tasks are quite different from those of radio navigation, both in terms of the sensor-motor cues required and ability of a desktop simulator to support them.

Third, this device was seen as being of very little use for tasks from Primary Flight Training that required hovering as a part of the flight maneuver. Experts and students alike rated

hovering tasks as unsupported or slightly supported. Hovering is an integral part of Primary Flight Training in IERW. Many tasks require achieving a stable hover, taking off from a hover, or landing to a hover. No evaluator was able to achieve a stable hover with the micro-simulator. The frustration was most noticeable with the high-time aviators who often refused to believe that they could "not make this thing hover." The device simply did not allow pilots, all of whom had proven repeatedly that they could hover the aircraft, to meet performance standards. The stated reasons for this were legion: lack of peripheral visual cues, lack of visual cues to depth, lack of correct flight control response, lack of a helicopter flight model, even lack of platform motion cues. Unfortunately, the verdict on hovering the device gets worse upon closer examination. Those expert aviators who were best able to control heading, height above ground, pitch, and drift while attempting to hover stated that what they were doing with the flight controls was in no way similar to how they would operate the flight controls in a helicopter. In other words, the likelihood of positive transfer from hovering the device to hovering the aircraft is doubtful. This result is unique, to date, because no other published research has been found that combines PCATDs with helicopter flight tasks.

Fourth, the results from the answers to the general questions were consistent with earlier research. Nine of the ten student evaluators (90%) had access to a PC at their place of residence. The result from an earlier assessment of Army IERW students was that 88% had access to a PC at their place of residence (S. Crouch, personal communication, February 8, 2001). The comparable data from Navy beginning flight students was 71% (Dunlap & Tarr, 1999). An Army-wide sample (ARI, 2001) found that 93% of all officers and 79% of all enlisted personnel had access to a PC at their place of residence. Four of the ten students (40%) had run a desktop flight simulator or aviation-related game prior to the evaluation. The result of an earlier Army IERW assessment was 34% (S. Crouch, personal communication, February 8, 2001). The figure for the Navy's beginning flight students was 47% (Dunlap & Tarr, 1999). At the very least these figures show that beginning flight students are computer literate and that a substantial minority are using PCATDs.

Finally, the results of this utility analysis should not be understood to mean that the evaluators or the authors are advocating replacing any current systems with a suite of PCATDs. This was not the purpose of the evaluation. The purpose of the evaluation was simply to determine if the micro-simulator under investigation supported the IERW Common Core curriculum. A discussion of how USAAVNC could approach integrating PCATDs into Flight School XXI does exist and is included at Appendix D.

Conclusions

1. The high-time aviators and the student aviators agreed very closely in their evaluations of the utility of the micro-simulator for IERW training.

2. The micro-simulator being evaluated:

    - Was rated as not able to support hovering tasks (cf., Tables 1, 2, and 5).

- Was rated as slightly able to support Primary Flight Training, especially upper air tasks (cf., Tables 1, 2, and 3).

- Was rated as able to support Instrument Flight Training moderately to well, especially radio navigation tasks (cf., Tables 1, 2, 3, and 4).

3. Evaluators reported in answer to a specific question, as well as in their spontaneous comments, that the simulator had promise as a procedures trainer for the instruments portion of IERW. Some also reported that it had value as a dynamic classroom aid for ground school instruction and as a practice device if located at the Learning Center.

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Appendix A

Rating Form

Name______________________________ Age_____ Total Flight Hours________

Job Title__________________________________ Date____________

Subject Matter Expert Evaluation: IERW Flight Tasks (from Flight Training Guides)

Part I: *Instructions*. How well does this low-cost micro-simulator (Desk Top Simulators RTC) support the following IERW Common Core Tasks? Please check one evaluation per task.

TASKS	EVALUATION			
	Not at all	Slightly	Moderately	Well
Phase I Primary Flight Training Stage I				
Straight-and-level flight	_____	_____	_____	_____
Climbs and descents	_____	_____	_____	_____
Turns	_____	_____	_____	_____
Acceleration/deceleration	_____	_____	_____	_____
Climbing and descending turns	_____	_____	_____	_____
Relationship of the flight controls and the instruments	_____	_____	_____	_____
Hover check	_____	_____	_____	_____
Hover power checks	_____	_____	_____	_____
Rectangular course	_____	_____	_____	_____
"S" turns	_____	_____	_____	_____
Hovering flight	_____	_____	_____	_____

Takeoff to a hover	_____	_____	_____	_____
Hovering turns	_____	_____	_____	_____
Landing from a hover	_____	_____	_____	_____
Traffic pattern flight	_____	_____	_____	_____
Traffic pattern entry	_____	_____	_____	_____
Traffic pattern exit	_____	_____	_____	_____
VMC takeoff (hover)	_____	_____	_____	_____
VMC (normal) approach (hover)	_____	_____	_____	_____
Approach termination procedure	_____	_____	_____	_____
Standard autorotation	_____	_____	_____	_____
Simulated engine failure at altitude (autorotation descent)	_____	_____	_____	_____
Power recovery	_____	_____	_____	_____
Go-around	_____	_____	_____	_____
VMC takeoff (ground)	_____	_____	_____	_____
VMC (normal) approach (ground)	_____	_____	_____	_____
Hovering autorotation	_____	_____	_____	_____
Simulated engine failure at hover altitude	_____	_____	_____	_____
Shallow approach to a run-on landing	_____	_____	_____	_____

Phase I Primary Flight Training Stage II

Simulated maximum performance takeoff	_____	_____	_____	_____

VMC (steep) approach	_____	_____	_____	_____
Slope operations	_____	_____	_____	_____
Termination with power	_____	_____	_____	_____
Low-level autorotation	_____	_____	_____	_____
Standard autorotation with 180-degree turn	_____	_____	_____	_____

Phase II Instrument Flight Training Stage I (Basic Instruments)

Instrument maneuvers:

Straight and level	_____	_____	_____	_____
Standard rate turn	_____	_____	_____	_____
Climbs and descents	_____	_____	_____	_____
Timed turns	_____	_____	_____	_____
Steep turns	_____	_____	_____	_____
Acceleration/deceleration	_____	_____	_____	_____
Climbing and descending turns	_____	_____	_____	_____
Unusual attitude recovery	_____	_____	_____	_____
Straight and level (EP)	_____	_____	_____	_____
Standard rate turns (EP)	_____	_____	_____	_____
Climbs and descents (EP)	_____	_____	_____	_____
Climbing and descending turns (EP)	_____	_____	_____	_____
Compass turns (EP)	_____	_____	_____	_____

Phase II Instrument Flight Training Stage II (Advanced Instruments)

ADF station identification	____	____	____	____
ADF aircraft position	____	____	____	____
ADF course interception	____	____	____	____
ADF course tracking	____	____	____	____
ADF holding	____	____	____	____
ADF approach	____	____	____	____
Radio navigation	____	____	____	____
ADF missed approach	____	____	____	____
VOR station identification	____	____	____	____
VOR aircraft position	____	____	____	____
VOR course interception	____	____	____	____
VOR course tracking	____	____	____	____
VOR holding station	____	____	____	____
VOR holding intersection	____	____	____	____
VOR approach	____	____	____	____
VOR missed approach	____	____	____	____
LOC/ILS station identification	____	____	____	____
LOC/ILS course interception	____	____	____	____
LOC/ILS course tracking	____	____	____	____
LOC/ILS holding	____	____	____	____
LOC/ILS approach	____	____	____	____
LOC/ILS missed approach	____	____	____	____

Instrument takeoff ____ ____ ____ ____

Part II: General.

1. All in all, I believe that simulation is an effective tool for initial flight training. (Please indicate your impression by placing an **X** in the appropriate box.)

Strongly Agree	Agree	Agree Somewhat	Disagree Somewhat	Disagree	Strongly Disagree

2. In the past year I have run a desktop flight simulator or aviation-related game on a personal computer (PC). (Such as Microsoft Flight Simulator, Strike Eagle, Falcon, or RAH-66 Comanche.)

_____Yes _____No

3. I have access to a PC at my place of residence.

_____Yes _____No

If you were in a decision-making capacity, how would you employ this micro-simulator for IERW flight training?

Appendix B

Answers to the Open-Ended Question

Answers recorded by the researcher to the question "If you were in a decision-making capacity, how would you employ this micro-simulator for IERW flight training?" These answers are accurate paraphrases and direct quotations.

Experienced Aviators

Evaluator A: As it sits, "not use it at all for flight training." Would be valuable in ground school, as a teaching aid in ground school.

Evaluator B: Procedural, procedures trainer both Primary and Instruments. Use it to supplement Primary and Instruments. Procedures training: flight instruments, cross check, navigation aid tuning and use, emergency procedures, system failures. It is a procedures trainer, not a flight simulator.

Evaluator C: It is "useless" for Primary contact phase. It is "very useful for instrument flight training" both flight instruments and navigation instruments.

Evaluator D: "It is a procedures trainer, an instruments trainer for navigation instruments, cross needles, location on the ground, instrument approaches, instrument techniques, identify stations, tune navigation aids, teach and learn navigation aids. It is not a flight simulator."

Evaluator E: "Instrument procedures only (and that with two students)." Flight instruments and navigation instruments. Need clock, torque gauge, flight package, and navigation aids. Do not need engine gauges, fuel gauge, oil gauge, and temperature gauges.

Evaluator F: Use it as a procedures trainer for flight controls, flight instruments, and "upper air work," not for hovering. Use it as a procedures trainer for "partial panel."

Student Aviators

Evaluator G: VFR—not useful; IFR—"pretty good, pretty useful." Basic Instruments "OK," navigation training "great." Use it for Instruments training.

Evaluator H: VFR—use for upper air work, but not hover. IFR—"pretty good tool" for training navigation instruments and flight instruments, BI, AI, procedures turns, etc.

Evaluator I: Use it as a classroom teaching aid or Learning Center practice tool. VFR—no comment. IFR—use for instruments, especially navigation instruments, BI, AI, "train basic concepts then transfer to flight simulator." Instruments procedures trainer.

Evaluator J: "For Instruments students." It is a "better tool for navigation, flight instruments." Not for VFR, it does not fly like a helicopter. IFR—"valuable training tool." Primary Flight Training it is "slightly useful."

Evaluator K: "Tool for Instrument students." Both navigation and flight instruments training, IFR. Not Primary Flight Training, not VFR, not the correct visual cues. "Nav stuff good," "two VORs at pilot station good."

Evaluator L: "Primarily for instruments. Best to take home and practice for instruments." Not helpful for Primary Flight Training.

Evaluator M: "Instrument flight training only." Not VFR.

Evaluator N: Instrument training of navigation aids. Not VFR. Best for instrument training. Good for instruments, not good for primary VFR. Some limited use for upper air procedural training.

Evaluator O: "Very suitable for instrument training." For hover work it is "not suitable."

Evaluator P: Not VFR. "Not Primary. Secondary or instruments, yes." "Maybe emergency procedures." No peripheral vision for VFR. Flight controls not correct for VFR. "Simulates instrument techniques, station IDs, approach plates, interpretation of instruments." Value as instruments. Should be located at Learning Center, for off-time, voluntary practice.

Appendix C

Positive Comments and Criticisms

This appendix contains the concerns and comments verbalized by aviators while evaluating the micro-simulator and recorded by the researcher. The comments of all 16 evaluators, both experienced aviators and students, were aggregated together. Only comments that were expressed by at least two aviators were included. Comments were grouped together if they expressed a common underlying theme.

Positive Comments

1. This is an instruments trainer. It should be used to train navigation instruments and navigation procedures. ("I wish I'd had this for instruments practice.") Fourteen (14) evaluators mentioned this theme.

2. This is a procedures trainer. It should be used to train basic relationships between flight controls and flight instruments, emergency procedures, partial panel. Seven (7) evaluators mentioned this theme.

3. This device is for training upper air work; normal flight procedures at altitude. Three (3) mentioned this theme.

4. This device would be useful for student stations in ground school academics or as a practice device at the Learning Center. Four (4) mentioned this theme.

5. With the addition of a large, classroom-size, projection screen, this device would be very useful ("excellent") for academic training in ground school. Two (2) mentioned this theme.

Criticisms

1. Flight controls. The cyclic position, seat position, and pedal positions are not comfortable, not adjustable, and not like the aircraft. This is especially true for the cyclic. The cyclic is positioned unnaturally. The pilot cannot relax and let his/her hand rest on the right thigh. It produces fatigue, back pain, and/or neck pain while trying to operate this device for any appreciable length of time. Ten (10) evaluators mentioned this theme.

2. Flight controls. The cyclic is a hindrance to flying this simulator. The cyclic has a spring that keeps trying to return it to the center position. It needs a force trim capability. The pilot cannot just set the force trim and leave the cyclic alone temporarily. The pilot must continually "fight" the cyclic. This is unlike the aircraft. The pilot must constantly move, adjust, press, and control the cyclic to maintain straight and level flight. It is more difficult to maintain straight and level flight in this device than in the aircraft. In addition, there is a null area in the cyclic center position of about two inches in diameter within which no command inputs have any impact. There is no such null area in the aircraft's cyclic. Eight (8) evaluators mentioned this theme.

3. Flight controls. The collective is unlike that of the aircraft. It needs force feedback. The collective should give feedback to the pilot concerning how much power he/she has pulled in. The collective is "too sensitive," "too jumpy" at the high end. The collective in the aircraft is not linear; the collective in the device is too linear. Four (4) evaluators mentioned this.

4. Flight controls. The pedals are unlike those of the aircraft. They are both stiff to move and insensitive to control inputs. Pilots have to "put in too much pedal." Pedals are not "responsive enough." Twelve (12) evaluators mentioned this.

5. Flight instruments. The Bell 206B Jet Ranger was the aircraft model used for this evaluation. The Bell 206B aircraft model does not have the same cockpit configuration as the Army TH-67. The evaluators wanted any simulator used in any capacity for IERW training to incorporate an accurate representation of the TH-67's flight instruments; the same instruments in the same locations for accurate instruments procedures training and accurate scan pattern development. Four (4) evaluators mentioned this. (The researcher chose the Bell 206B model for the evaluation because it was a higher quality, more readable, and scalable model of the flight instruments than the TH-67 model available. Thus, *this criticism is not fair to the micro-simulator under evaluation*. The device would have been able to run a higher quality TH-67 model if one had been available.)

6. Flight instruments. The flight instruments lag the flight controls. This is not like the aircraft and not good. When the instruments lag the controls a pilot's feedback is reduced and this can cause pilot induced oscillations of the aircraft. Aviators remarked that this situation was particularly notable during instrument takeoffs and acceleration/deceleration. Ten (10) evaluators mentioned this.

7. Flight instruments. Simulator would be of greater value with a clock that can be set/reset with a button to time approaches, holding patterns, etc. Two (2) evaluators mentioned this.

8. Flight instruments. The turn indicator moves too much; is too sensitive to cyclic inputs. It acts like the turn indicator in a fixed-wing aircraft rather than a helicopter. Two (2) evaluators mentioned this.

9. Visual cues. The instruments-in-the-windscreen approach used by Microsoft has some drawbacks. It reduces field of view. It blocks part of the view out the front on an approach, causing the pilot to adjust the pitch up and down to see the landing site ("porpoise"). It reduces visual cues needed to hover. When the instruments are scaled well down in size or pushed "below" the screen, then the pilot loses his/her instruments. Aviators wanted the instruments below the windscreen, either on another monitor or actual instruments. A related complaint was that pilots could not see below themselves for hovering and approach. They wanted something to simulate the "chin bubble" available in helicopters. Twelve (12) evaluators mentioned this.

10. Visual cues. Everyone wanted peripheral visual cues, wider field of view, and a view out the right and left doors. VFR tasks require better simulation of peripheral cues for hovering drift,

traffic pattern flight, traffic pattern entry/exit, rectangular pattern, S turns, autorotation, and more. All sixteen (16) evaluators mentioned this theme.

11. Visual cues. Better visual cues to depth. Height above ground was difficult to judge visually. Height above terrain is a necessary visual cue for VFR helicopter flight. Among the tasks where it is essential are hovering tasks, approaches, and autorotations. Fourteen (14) evaluators mentioned this.

12. Flight model. The micro-simulator does not hover. None of the evaluators could achieve a stable hover. The simulator was reported to be much harder to hover than the helicopter itself. Criticisms concerned the flight controls and the mathematical flight model. Twelve (12) evaluators mentioned this theme during operation of the simulator.

13. Flight model. The micro-simulator does not "fly" like a helicopter at low indicated air speeds. It does not react to control inputs at low speeds the way a helicopter does. It acts "squirrelly" at low speeds. One evaluator, an expert, said it "gets stable above 60 knots, which means it is using a modified fixed-wing flight model." The point is that a helicopter is stable at low air speeds, or even zero air speed. Four (4) evaluators mentioned this.

14. Flight model. It does not turn like a helicopter. This is especially true for steep turns and ascending/descending turns. Two (2) evaluators mentioned this.

Appendix D

PCATD Study Group Report

The Potential Use of PCATDs as an Adjunct to Initial Entry Rotary-Wing (IERW) Flight Training[1]

PCATD Study Group[2,3]

The Mission of the PCATD-JWG

The mission of the Personal Computer Aviation Training Device (PCATD) Joint Working Group (JWG) as stated in the draft charter (Stewart, 2000) was, in part:

> This could involve, but is not necessarily limited to, an evaluation of training outcomes using PCATDs based upon current off-the-shelf, commercially available flight simulation software. The evaluation will take place within the context of the training system as a whole. The committee will provide input in the form of recommendations for the optimal employment of PCATDs in the aviation training system of the 21st Century. (Stewart, 2000, p.1)

In an email to the JWG Thomas Flohr said that the mission "is to determine what PC based system is capable of improving and enhancing current and future POI training to obtain a better qualified pilot" (T. Flohr, personal communication, October 6, 2000).

Given either of these wordings the mission of the PCATD-JWG was open to a wide variety of interpretations (and misinterpretations). Hence, a small Study Group was formed from a subset of volunteers attending the JWG meeting of 2 October 2000. This PCATD Study Group (hereafter referred to as "Group") read, thought, and engaged in productive dialog in an attempt to structure the PCATD issue for the JWG.

The Group was able to winnow down the many potential uses of PCATDs to a few which appeared practical, and then present these options to the JWG. The Group made its initial presentation to the JWG on 17 January 2001. As a result of that presentation the Group was encouraged to evaluate a commercial micro-simulator PCATD manufactured by Desk Top Simulators of Fort Worth, Texas. This micro-simulator evaluation has been performed, briefed, and reported (PCATD Study Group Interim Report, 23 August 2001). A brief discussion of this evaluation is included as a part of Option Three (below).

The Group concluded that there are three potentially valuable approaches to the use of PCATDs in IERW training. PCATDs can be used for self-study by students prior to flight school, they can be used in ground school academics as a dynamic interactive aid for teaching key concepts, and they can be used to support the training of instrument procedures. These approaches are not mutually exclusive. One or all of them can be employed in an effort to improve student proficiency, early in flight training, with little or no modification of the current curriculum.

Potential Options for Training that the PCATD-JWG Could Consider Pursuing

Option One: Informal self-study using commercially available flight simulation software. The United States Army Aviation Center (USAAVNC) could provide inexpensive PCATD software to students prior to their beginning flight school at Fort Rucker. Along with the software USAAVNC could provide a simple printed syllabus explaining to students how they should use the software for prerequisite learning prior to flight school. Students would gain knowledge of aviation vocabulary, concepts, flight instruments, and navigation instruments. The intent of this would be to increase student knowledge, and readiness to learn, before the formal course of instruction began.

[1] This report is not the official position of the United States Army Aviation Center.
[2] The members of the PCATD Study Group were: William Barker (ARI), Stephen Crouch (LSI), Thomas Flohr (DOTDS), David Johnson (ARI), Edward Miller (ATB), John Stewart (ARI), Willard Vignoe (DOTDS), and Dale Weiler (ARI).
[3] David Johnson and John Stewart wrote this report.

There are at least two media that could be used to provide this "head start." Both CD-ROM and the Internet could be used, and both have been used in the past. There are a number of low-cost CD-ROM based flight simulator packages available. Microsoft Flight Simulator 2000™ Professional Edition, for example, contains a CD plus a textbook with flight training tutorials, homework assignments, and a glossary of aviation terms. The Navy provides a modified version of Microsoft Flight Simulator 2000™, plus access to a custom website (NROTC Zone, found at www.cnet.navy.mil/microsim/), to every Navy flight student and every member of Naval ROTC at all 65 campuses. This Navy program has been in operation since 2000.

This option assumes that virtually all flight students have access to a PC at their place of residence. Research shows that they do. In the micro-simulator evaluation referred to earlier it was found that nine of the ten student evaluators (90%) had access to a PC at their place of residence. The result from an earlier assessment of Army IERW students was that 88% had access to a PC at their place of residence (S. Crouch, personal communication, February 8, 2001). The comparable data from Navy beginning flight students was 71% (Dunlap & Tarr, 1999). Finally, an Army-wide sample (ARI, 2001) found that 93% of all officers and 79% of all enlisted personnel had access to a PC at their place of residence. Thus, since virtually all flight students have access to a PC, Option One should not be limited by computer illiteracy on the part of the students.

Would students use the PCATD materials provided at government expense or not? There is a certain amount of evidence that says they would. First, research has shown that highly capable students do well in an unstructured, self-study environment (e.g., Cronbach & Snow, 1977). Second, computer literate students of the present generation are comfortable in a self-study environment because that is how they have been learning their computer skills since grade school (e.g., Prensky, 2001; Schaab & Moses, 2001). Third, many flight students are using these materials on their own already. Four of ten students (40%) had run a desktop flight simulator or aviation-related game prior to the micro-simulator evaluation (PCATD Study Group Interim Report, 23 August 2001). The result of an earlier assessment of Army IERW students was 34% (S. Crouch, personal communication, February 8, 2001). The comparable figure for the Navy's beginning flight students was 47% (Dunlap & Tarr, 1999). Thus, it is likely that primary flight students would take advantage of any PCATD materials provided to them prior to school—especially since these materials would arrive with the clear imprimatur of USAAVNC.

USAAVNC could institute this option on an experimental basis in order to determine if, in fact, IERW students were arriving better prepared for school and performing at a higher level while in school. There are at least two research approaches that could be considered. PCATD Option One could be instituted for every IERW class for a year. The performance of students in these experimental classes could be compared to historical records of student performance using the standard, PCATD-less curriculum. Academic classroom instructors, primary flight instructors, and instruments instructors could be interviewed as to their professional opinion of the experimental students versus past students. A second approach would be to employ a formal experimental methodology and compare PCATD classes to standard control classes. ARI would be available to consult with USAAVNC on research methods, measures, and analyses. In addition, if a bona fide research plan were in place, ARI could purchase any number of PCATD flight simulator software packages with funds transferred for this purpose through Military Interdepartmental Purchase Request (MIPR).

This option is the easiest to implement. It does not require any changes to any part of flight school. The POI and instructor force are unchanged. It does not require modifications of classrooms, refurbishing old buildings, or new construction. It does not even require additional electrical power.

<u>Option Two: Upgrade Classroom Instruction in Ground School with the Addition of Commercially Available PCATD Flight Simulation Software</u>. Academic instruction in ground school for IERW currently uses the "sage on the stage" pedagogical technique—lectures, slides, and tests. This technique is both effective and efficient. It is a valid method of getting information to large groups of students and it has been doing so for 200 years (cf., Prensky, 2001). It can be improved upon, however, in a number of ways—most of which are not the focus of this Group report. One technique that would improve classroom instruction, while leaving virtually the entire academic POI unmodified, is simply to improve the teaching aids available to the platform instructor. A PCATD being run by a suitably powerful computer with the screen display being projected onto a classroom sized display is one such teaching tool.

There are few activities in life more dynamic, interactive, and three-dimensional than that of flying a helicopter. A PCATD flight simulator program can be used by an instructor to show, in real time, key concepts from his or her lectures embedded in an integrated flight environment. A PCATD flight simulator can be used to provide dynamic, interactive, three-dimensional examples of what the instructor just said. It can be used as a powerful teaching tool without requiring new instructors, new classrooms, or a new POI.

An example may be pertinent here. Training Module G of the IERW POI (USAAVNC, May 1996) is called Instrument Academics and it is intended "To provide the student with a working knowledge of those subjects required for a rotary-wing instrument qualification." (USAAVNC, May 1996, p.27) It contains instructional sub-modules entitled: holding procedures, approach procedures, attitude instrument flying, introduction to radio navigation, radio magnetic indicator, radio navigation/horizontal situation indicator, and others. Module G is intended to give the student the academic information necessary to learn basic instruments flying and advanced instruments radio navigation.

The Bell 206B helicopter model included as a part of Microsoft Flight Simulator 2000™, a common inexpensive PCATD, contains functional flight and navigation instruments, including: indicated airspeed, attitude indicator, barometric altimeter, vertical speed indicator, turn indicator, trim ball, compass, horizontal situation indicator, automatic direction finder (ADF), two very high frequency omni-directional radio range receivers (VORs), tunable navigation radios with Morse code identification and distance measuring equipment (DME), a clock, and inner/middle/outer markers, among other instruments. These flight and navigation instruments operate in real time and function the way the actual instruments function in the aircraft. The geographic database contained in Flight Simulator includes the non-directional beacon (NDB), VOR, localizer, and instrument landing system (ILS) transmitter frequencies and ranges. Airports are modeled in the database with all runways correctly oriented to magnetic heading. This means that the classroom instructor could use this PCATD to demonstrate concepts related to attitude flying; standard rate turns; tuning, identifying, position identification, intercepting, and tracking an NDB, VOR, localizer, or ILS; holding patterns; or intersection holding. The instructor could show the ADF needle spinning 180 degrees when the PCATD is made to simulate flying over an NDB, for example, all in real time and all interactively under control of the instructor. Key academic concepts could be demonstrated using a PCATD as a dynamic, interactive, three-dimensional teaching aid.

This approach would increase the concrete illustrative quality of the ground school instruction. The PCATD when controlled by the instructor would provide clear, compelling, real time examples of some of the course content. It should increase the richness of the mental flight model that the students develop as a result of their ground school instruction. This option would shorten somewhat the bridge from the classroom to the flight line.

Academic instruction is scheduled for 95 of the 100 training days devoted to Primary Flight Training and Instrument Flight Training (USAAVNC, 2000). Option Two does not require any modification to the academic POI. However, the usefulness of the classroom PCATD would only increase if additional classroom time were made available for its use. Are there any classroom content hours that could be shifted, modified, or shortened? For example, ten days of academic instruction are devoted to aviation weather. For another example, one day is devoted to platoon training. Is IERW really the best place to put this platoon training? Platoon training, some would suggest, properly belongs in Basic Combat Skills. The point is simply this: the advantages to IERW that would accrue by use of a PCATD during academic instruction would increase with increasing use—and use takes time. Increasing the classroom time available for essential flight instruction would be a good thing, if possible.

To implement this option the classroom computers currently being used for ground school would need to be upgraded. While the current systems are adequate for projecting Microsoft PowerPoint™ slides, they are too slow for regular classroom use of a PCATD flight simulator program. It is the experience of the Group that a host computer with an Intel Pentium III™ processor, operating at a speed of 550MHz, with 256MB RAM, can run the PCATD with no irritating delays between control input and response. The instructor station would also need a joystick to input control commands comfortably. Keyboard input to the PCATD is not an acceptable interface (cf., Norman, 1998) and has been shown to reduce learning and transfer (Dennis & Harris, 1998).

The expert aviators who currently teach academics would need a block of instruction on the PCATD as a part of implementing Option Two. This step cannot be ignored. Instructors who have not had an opportunity to learn the PCATD software will simply not use it. However, learning how to operate the Microsoft Flight Simulator 2000™, for example, is neither difficult nor time-consuming. This is one of the many advantages of commercial PCATDs. Besides being inexpensive and reliable, they are designed to be easy to learn, easy to operate, and relatively forgiving of errors. Vendors design their PCATD products to be "flown" out of the box by ordinary consumers who are neither engineers nor aviators.

Option Three: Provide Commercially Available PCATD Micro-Simulators for IERW Student Practice. Why should any student who has successfully passed Primary Flight Training fail Instrument Flight Training? Why should any student who has learned how to hover and fly a helicopter solo under visual flight rules fail instruments? Why should a student who can fly a helicopter not be able to master the largely knowledge-based, procedural skills taught in instruments? Some students may simply need extra practice to grasp these procedurally and cognitively

complex tasks. PCATDs provide a low-cost vehicle for providing students extra practice prior to and during Instrument Flight Training.

Options One and Two refer to simple, desktop PCs running inexpensive CD-ROM flight simulator applications and being controlled by a joystick. Option Three calls for PC-based micro-simulators. These micro-simulators are near the high end of the PCATD continuum. They are PC-based, desktop simulators with seats, flight controls, and sometimes even physical switches, knobs, and dials. One exemplar of this type of procedures trainer is the Rapidly Transferable Cockpit (RTC) made by Desk Top Simulators and evaluated by the Group (Study Group Interim Report, August 23 2001). The RTC evaluated by the Group is described below in order to give the reader an impression of the kind of device that is meant when one refers to a micro-simulator.

Each RTC weighed approximately 500 pounds (227 kg.). Its dimensions were 72 inches (183 cm.) in length, 34 inches (86 cm.) in width, and 60 inches (152 cm.) in height. It used standard 110 V, 60 Hz power. The visual display monitor measured 28 inches (71 cm.) diagonally. The angular field of view of this screen from a normal sitting position was 43 degrees (horizontal) by 34 degrees (vertical). This CRT screen had a resolution of 768 pixels horizontally by 1024 lines vertically. The RTC was capable of supporting a wide variety of PC-based flight simulator software applications. The evaluation was limited to Microsoft Flight Simulator 2000™ Professional Edition. The software was run on a Microsoft Windows 98™ operating system. The host computer was an Intel Pentium III™ processor, operating at a speed of 550MHz, with 256MB RAM. The system included a Logitech wireless keyboard, a Logitech wireless mouse, and two Juster Multimedia speakers. The RTC contained a padded seat facing the CRT screen and operational flight controls. The cyclic was a Stick II made by Flight Link. Flight Link also made the collective and the pedals.

The interested reader should examine the report referenced above to learn the details of the utility evaluation performed and the results obtained. In brief, a sample of expert and student aviators evaluated the capability of the micro-simulator to support training of IERW flight tasks. They rated the micro-simulator as being able to support Instrument Flight Training moderately to well. They were much less satisfied with the capability of the micro-simulator to support Primary Flight Training, without major modifications to the visual system, database, and flight model.

The report also listed a body of research showing the validity of PCATD micro-simulators for fixed-wing visual flight rules (VFR) training and fixed-wing instrument flight rules (IFR) training. The report noted that the Federal Aviation Administration allows certified PCATDs to be used for creditable training for the private pilot instrument rating (cf., FAA, 1997). The interested reader of the Interim Report will learn that PCATD micro-simulators are now a valid and accepted part of aviation training in the private sector and the Navy.

Option Three is a proposal to extend PCATDs to IERW training in the form of a student procedures trainer for the practice of instrument techniques. The suggestion is to provide a student micro-simulator laboratory at the Learning Center or some other accessible location on Fort Rucker. Students could use the PCATDs to practice basic and advanced instrument procedures voluntarily, on their own time, after training hours. The Group is not suggesting in this document any change to flight line helicopter training or instruments simulation at Pratt Hall. This is merely an adjunct to standard IERW training. It is an opportunity for the students who need extra practice in instrument procedures to have some place to get that practice.

The Option Three micro-simulator lab should not require significant maintenance or supervisory resources. The PCATDs are fundamentally desktop computers running a flight simulator application from a Microsoft Windows™ operating system. This means that they have in common with PCs both ease of use and reliability. During three months of dedicated testing the RTC evaluated by the Group never experienced any problem that could not be solved by simply rebooting the system. Further, since these PCATDs are little more than upgraded PCs, the researcher (David Johnson) required only a very few hours of practice to learn how to operate the system, preset test flight conditions, record flights, and modify the system settings. Virtually any "bubble student" (a flight student who has finished Primary and Instruments and is awaiting assignment to Basic Combat Skills training, for example) could be trained how to operate and maintain the PCATDs in one day and then supervise the micro-simulator lab for the duration of his or her bubble period. USAAVNC would have no difficulty finding a crew of bubble students who are both computer literate and available for this aviation-relevant assignment. Finally, since these PCATDs are merely modified PCs, they do not have special power, temperature, or humidity needs. They can be plugged into a power strip and operate in virtually any building on Fort Rucker.

Option Three could easily have other, unanticipated advantages. For example, what about those many days each year when weather prevents flight line training? Or, what about those crews who cannot train on a given day because of aircraft unavailability? In each of these cases having procedures trainers available and accessible could mean the difference between a productive day and a lost day. Enterprising instructor pilots (IPs) could (and would) take their students to the micro-simulator lab and give them a block of instruction on something. Perhaps the IPs

would use the time to introduce a concept or technique that will be trained later. For example, all of the micro-simulators have a visual system. IPs would soon learn to use them for introducing students to VFR tasks when aircraft were unavailable for any reason. The unanticipated advantages of having a dedicated simulator training facility for IERW will surely grow over time.

Finally, Dennis and Harris (1998) will be quoted below since their wisdom deserves to be repeated over and again when discussing micro-simulator PCATDs:

> Despite evidence that low-grade simulation is beneficial in the early stages of pilot training, there is still a real requirement for instruction to take place in the air to expose trainees to the flight environment. For this reason, it is suggested that simulation should be used as an adjunct to training in the air and not as a replacement for it. The objective of using low-cost simulation in the initial stages of instruction should be to maximize the quality of instructional time in the air. (Dennis & Harris, 1998, p. 263)

Now is the Time

Providing students with extra, preparatory, aviation materials for self-study is not "rocket science." Using a classroom simulator to demonstrate flight instruments and navigation instruments is not rocket science. Using a low cost micro-simulator to allow students to practice instrument skills is also not rocket science. These are basic pedagogical techniques whose usefulness is almost certain to be shown in future Navy, Air Force, and Army research. What makes these techniques valuable at the present time is not the instructional theory underlying them, for this has not changed. The value in these techniques lies in the enormously capable simulator technology that can now be purchased relatively inexpensively.

Voltaire said in 1764 "The best is the enemy of the good." He was referring to the very human tendency of people to keep delaying decisions about good simulator technology because better technology is right around the corner. There will always be better technology around the corner. Technology always improves over historical epochs (cf., Burke, 1978). This should not prevent us from deciding upon good technology today.

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Acronyms

ADF	Automatic Direction Finder
ARI	US Army Research Institute for the Behavioral and Social Sciences
ATB	Aviation Training Brigade
CRT	Cathode-Ray Tube
DME	Distance Measuring Equipment
DOTDS	Directorate of Training, Doctrine, and Simulation
EP	Emergency Panel
FOV	Field of View
FTG	Flight Training Guide
IERW	Initial Entry Rotary Wing
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IP	Instructor Pilot
JWG	Joint Working Group
LOC	Localizer
LSI	Lear Siegler Services Incorporated
MIPR	Military Interdepartmental Purchase Request
NDB	Non-Directional Beacon
NROTC	Naval Reserve Officer Training Course
PCATD	Personal Computer Aviation Training Device
POI	Program of Instruction
RTC	Rapidly Transferable Cockpit
USAAVNC	US Army Aviation Center
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omni-Directional Radio Range Receiver